New Zealand Department of Agriculture.

Guide to the Mycological Exhibit,

New Zealand and South Seas Exhibition, 1925-26.

BY

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GUIDE TO THE MYCOLOGICAL EXHIBIT,

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By G. H. Cunningham, Mycologist, Wellington.

The object of this publication is to explain briefly the exhibit arranged by the Mycological Section of the Department of Agriculture.

Mycology is that science which deals with the study of fungi; and, as the major number of plant-diseases are caused by these organisms, it has come to embrace the study of plant-diseases, their cause and remedial treatment. In addition, the mycologist deals with bacterial diseases of plants, together with a group of diseases—termed "non-parasitic" or "physiological" diseases—whose causes are obscure or unknown.

WHAT FUNGI ARE.

Fungi and bacteria are lowly plants, which, being unable to manufacture their foods (on account of the absence of chlorophyll), must obtain them from living or dead plant or animal tissues. A typical fungus is the common field mushroom. The portion above ground, known as "stalk" and "cap" (Fig. 1), is given over to reproduction; for from the lower surface, on the gills, are produced quantities of spores or reproductive bodies performing a similar function to the seeds of higher plants. These spores are produced in enormous numbers, and when matured are forcibly discharged from the gills. Before they reach the surface of the ground they are caught by air-currents (being exceedingly light) and carried long distances. When they alight, should conditions prove favourable, they may germinate and give rise to a vegetative stage which eventually produces further fructifications. The stalk serves as an elevating organ whose function is to carry the cap sufficiently high to enable the spores to be dispersed by the wind.

Beneath the soil ramify countless thread-like structures termed "hyphæ" (Fig. 1): these are attached to the stalk, and penetrate between the soil-particles. The hyphæ collectively form the vegetative portion (known as the "mycelium") of the fungus. They perform the functions of nutrition, for they absorb from the soil and vegetable debris the food substances necessary for its growth and development. A hypha is tube-like, and is

divided at frequent intervals by cross-walls or septa; each is exceedingly fine, being on an average less than $\frac{1}{2500}$ of 1 in. in thickness. The cap and stalk consist of masses of these hyphæ so interwoven as to form a tough structure.

It has been shown that a mushroom obtains its food substances from decaying vegetable debris in the soil; owing to this method of nutrition it is termed a "saprophyte," and is said to lead a saprophytic existence. The majority of fungi lead a saprophytic life, and, together with certain bacteria, release the chemical substances stored in dead vegetable and animal tissues. Such saprophytic fungi and bacteria play an important part in nature, for were they absent decay of such matter could not occur.

The fungi which cause plant-diseases are essentially similar in structure to the mushroom, but differ on account of their (usually) much smaller size and parasitic habit. By way of an example a fungus causing leaf-spot of clover and lucerne has been chosen. On the leaves of these plants may be noticed numerous minute brown spots, which, on account of their small size, are frequently overlooked. Microscopic examination shows the leaf-cells of a spot to be brown and shrunken, an indication that they are dead; and it is these dead brown cells which give to the spot its characteristic appearance.

The hyphæ of the fungus causing the spot penetrate between the cells of the leaf and absorb from them the food substances contained therein. In consequence the cells die, and turn brown. These hyphæ are similar to, if not identical with, those of the mushroom, and perform similar functions—*e.g.*, those of obtaining from the host plant (the plant attacked by a pathogenic organism is termed the "host") their food substances.

After the parasitized cells have been killed the hyphæ within this region become aggregated into small masses, and finally give rise to a minute flask-shaped structure, from the interior of which spores are produced (Fig. 2). This structure is the fructification, which, although very different from the cap of the mushroom, yet performs the similar function of spore-production.

Spore-dispersion with such an organism is effected in quite a different way. The small flask-shaped structure (termed a "perithecium") is provided with a minute apical pore, and when the spores are ready for dispersal this opening is seen to protrude through the surface of the dead tissues, and through it the spores are ejected, to be carried by rain-splashes, insects, or even wind, to adjoining leaves.

This fungus lives at the expense of the living cells of the leaf—therefore it is termed a "parasite," and is said to lead a parasitic existence.

In both the mushroom and the fungus producing the leaf-spot two tissues are present:—

(1.) A vegetative tissue, consisting of numerous hyphæ, which penetrate soil, decaying vegetable or animal matter, or living plant or animal tissues; and

(2.) A reproductive tissue, formed for the purpose of producing structures (spores, &c.) capable of reproducing the fungus.

We have considered two types of fructification, both belonging to types of fungi which possess but one reproductive stage. With the great majority, however, one or more different stages of fructification are interpolated in the life-cycle before the final stage appears.

In general there are two types of fructification produced: the first stage—termed the "conidial" stage—being concerned with the rapid production of spores (here termed "conidia") during the growing season of the host, or, in the case of saprophytes, the (usually) warmer months of the year; the second type, or resting type, serving to carry the organism over some unfavourable period—usually during the winter, when leaves, fruits, &c., are not present. With parasitic fungi it is frequently the conidial stage (often also termed the "summer" stage) which is the actively parasitic one, the overwintering stage appearing on the dormant or dead tissues of the host, or on or in the ground.

With those fungi known as the "rusts" the life-cycle is even more complex, for as many as four spore stages may be produced; and is further complicated in that some require more than one host for the completion of the cycle, as with black-rust of wheat.

Conidia are simply modified portions of hyphæ rounded off as spores, and are usually borne on simple modified hyphal branches—termed "conidiophores"—from which they may at maturity be readily detached.

Resting fructifications, on the other hand, are more complex, and are completed only after they have undergone certain complex changes (which need not be discussed here). With certain fungi, however, the conidial stage is wanting (for example, the leaf-spot fungus discussed above), and in such cases, although a resting stage is formed (or, at least, a fructification exactly resembling such a structure), it functions more like a conidial stage, producing spores immediately it reaches maturity. These spores infect other leaves, and in turn fructifications arise, and so on until the late autumn, when a late-produced perithecium functions as a resting fructification.

The gradual development from the simple to the complex type of fructification is shown by Figs. 2 to 7.

The first (and simplest) stage is a simple, modified hypha (conidiophore) producing conidia from its apex. The conidiophore arises as a vertical branch of the mycelium, which with this species traverses the leaf-surface (Fig. 3, *a*). A septum is formed some little distance below the apex, cutting off portion of the hypha, together with its contents. This becomes rounded off, and finally detached as a single-celled spore or conidium. Such a type of conidial production is common to the mildews.

A slightly more complex form arises when the conidiophore becomes branched, as is shown in Fig. 3, *b*. Or the hyphæ may become interwoven, forming a cellular mass known as a "stroma," from the free surface of which arise the numerous simple or branched conidiophores arranged in

palisade fashion. This structure—termed an "acervulus"—is in reality a compound conidiophore (Fig. 5).

The hyphæ within or upon the tissues may produce a flask-shaped or globose structure, which, if it contains spores borne on simple hyphal branches growing from the inner walls, is termed a "pycnidium"; or, if the spores are borne in sacs arising from the same position, is termed a "perithecium," the sacs "asci," and the contained spores "ascospores." If a perithecium were cut in half by an equatorial incision, a structure resembling an apothecium would be produced (Fig. 6).

Perithecia or pycnidia may be in turn embedded in a mycelial mass, and may be solitary or in groups of several, and may open to the surface by one opening common to all, or by numerous individual openings (Fig. 7).

Thus one may trace the gradual evolution of the spore-producing structures (fructifications) from the simplest to the most complex type. The fact must not be lost sight of, however, that fundamentally the fungus consists of the two tissues mentioned above—vegetative and reproductive tissue—and that, however complicated the reproductive structure, its function is one of reproduction only, although certain of the more complex structures serve in part as resting-organs, protecting the spores within from extremes of heat or cold and desiccation.

Certain types of fungi have the spores borne on short stalks on club-like bodies termed "basidia" (Fig. 11). Such a type is the mushroom, where the basidia are arranged in palisade fashion over the surface of the gills—plate-like structures on the under-surface of the cap. With those fungi known as "shelf" or "bracket" fungi, common on certain trees in our forests, the basidia line the interior of stratified tubes on the under-surface of the shelf-like outgrowth.

The spore produced from any one of the fructifications discussed above may be carried to some suitable host in the vicinity, where, should conditions prove favourable, it may germinate (Fig. 8).

The method of penetration of the substratum differs according to the species, and to the host or part thereof attacked. If the fungus is capable of attacking a leaf, the hypha may penetrate directly through the surface (epidermis) to the tissues beneath, or may enter through one of the breathing-pores (stomata) on the surface (usually the under) of the leaf (Fig. 9). It may then penetrate between the cells, sending suckers (haustoria) into each (Fig. 10) and absorbing food substances in this manner, or else penetrate between the cells and absorb the foods by a process known as "endosmosis." The hyphæ of certain species penetrate directly through the cells, dissolving their way, as it were, by the secretion of certain substances from their apices. In all cases, once penetration has been effected, the hypha branches repeatedly, so that in a short time the whole of the area of penetration is permeated with hyphæ (Fig. 12).

In the mildews the mycelium remains on the surface and the fungus obtains its foods by sending through the epidermis of the host small suckers (haustoria) into cells beneath (Fig. 13).

Certain fungi are incapable of penetrating directly through living tissues, and must make entry to the host first by way of dead tissue—such as is present on the surface of wounds in branches of fruit and forest trees. The spore of such a fungus develops a hypha in the usual manner, and this penetrates the dead tissue and there branches repeatedly until a mycelium is formed (Fig. 12). This mycelium lives saprophytically in the dead tissues for a time, and then penetrates to the living tissues, where certain of the hyphæ enter into and block completely the conduction - vessels (xylem) of the host, preventing upward passage of water and soil-solutes. As a result the branch above the affected area dies, when the fungus grows into this killed portion and again lives saprophytically.

The spores are carried to other hosts in the vicinity in various ways. For example, the naked conidia of mildews are readily detached by wind and carried to other hosts, as are the spores of bracket fungi, mushrooms, &c.; others are distributed by insects, being accidentally carried on their bodies. Birds also may carry spores attached to their feet, limbs, or beaks. With those fungi producing spores in pycnidia or perithecia embedded in the tissues it is necessary the spores reach the surface before they can be dispersed by wind or other agency. This is effected in one of two ways. In certain of these receptacles is present a tissue which becomes gelatinized at maturity of the spores. This gelatinous substance has the property of being able to absorb moisture, consequently in damp weather it swells and is forced out of the receptacle in the form of a long slender tendril, carrying with it the embedded spores (Fig. 14). The matrix is then dissolved away by rain, and the spores either carried to adjacent leaves, &c., by rain-splashes or (when dry) by wind. With others the matrix swells to such an extent that the whole receptacle explodes with violence, the spores in this manner being dispersed. Others, again, are so constructed that the spores are shot out, either one by one or in small groups from the sacs (asci) with considerable violence. Once free from the receptacle they are carried by air-currents to adjacent hosts.

Fungi may overwinter in numerous ways. For example, in certain species causing rot of fruit or bulbs, certain thick-walled cells are produced from the hyphæ with which the tissues are permeated. These structures, which may remain in a quiescent condition for a considerable time, are termed "chlamydospores" (Fig. 15).

One of the most frequent methods of tiding the fungus over unfavourable periods is by the production of sclerotia (Fig. 16). These are simply masses of closely interwoven hyphæ with a thickened outer layer produced to protect the inner tissues from desiccation. The hyphæ in the central portion become partly gelatinized and filled with reserve food. Such structures are capable of remaining in a living condition in the soil for several years.

In certain fungi the perithecia or pycnidia function as overwintering structures, remaining viable when conditions are unfavourable (such as during the winter months, when no foliage and fruit are present) and producing spores when conditions are favourable.

Finally, certain fungi may overwinter in the form of resting mycelium in or on the host: for example, powdery mildew of fruit-trees overwinters by means of resting mycelium in the fruit-buds; and late blight of potatoes by means of resting mycelium in the tubers.

EXPLANATION OF EXHIBITS.

Exhibits 1 to 16 are drawings (diagrammatic) illustrating the structure of the various fungi discussed in the preceding introduction.

1. Field-mushroom (*Psalliota arvensis*).
   Drawing showing cap, stalk, gills, spore-cloud, mycelium (in ground), and on the right a developing plant.
2. Fungus causing Leaf-spot.
   Drawing of a fructification embedded in the leaf-tissues. Within the fructification (perithecium) may be seen the sacs (asci) containing spores, which at maturity escape through the opening at the apex.
3. Conidiophores bearing Conidia.
   On the left is a chain of conidia; on the right a branched conidiophore.
4. Branched Conidiophore.
   In this species the spores are produced in bunches, resembling bunches of grapes.
5. An Acervulus.
   This structure is in reality a compound conidiophore.
6. An Apothecium.
   This drawing shows stalk, cup, and the spore-bearing layer or hymenium.
7. A Compound Stroma bearing Perithecia.
   In this complex structure are several flask-shaped structures or perithecia. Such structures serve admirably as overwintering organs.
8. Spores and Spore-germination.
   On the left are several types of spores; on the right is a spore germinating and producing an infection hypha.
9. Penetration of Tissues: Direct Penetration.
   This illustration shows direct penetration, in which the infection hyphæ grow directly through the tissues.
10. Penetration of Tissues.
    Here the hyphæ grow between the cells and send small suckers (haustoria) into the cells.

11. Hymenium and Basidia.

Upon the basidia the spores—usually four in number—are borne.

12. Mycelium in Wood Cells.

The drawing shows their relative sizes and the method of penetration of the hyphæ.

13. Mycelium on Leaf-surface.

This shows the hyphæ (coloured brown) producing upright conidiophores, and suckers penetrating into the cells of the leaf.

14. Pycnidium in Leaf.

The receptacle is immersed in the leaf-tissues, so the spores are carried out embedded in a gelatinous tendril.

15. Chlamydospores.

These structures serve to tide certain fungi over an unfavourable period, acting in this connection as temporary resting-organs.

16. Section of a Sclerotium.

A structure by which many fungi—especially soil fungi—carry over an unfavourable period, or which may, with certain species, serve as a reproductive structure.

SELECTED FUNGI.

Exhibits 17 to 31 are photographs (enlarged) of certain fungi selected to show the numerous forms possible, and also to exhibit the diversities of life-histories.

17, 18, 19. "Earth-stars": 17, *Geaster triplex*; 18, *Geaster fenestriatus*; 19, *Geaster campester*.

These fungi are common throughout lowland areas of New Zealand, and may be found on vegetable debris in the forest, under hedges, or in open pastures. Seven species are found in New Zealand, and twenty-three in Australia, the richest country in the world for this subclass of fungi.

20, 21, 22, 23. "Bird's-nest" Fungi.

These fungi also occur on decaying vegetable debris on the ground. The spores are contained within the peculiar bodies (peridiola) seen in the cups. Eight species, belonging to three genera, are found in New Zealand: 20, *Cyathus stercoreus*; 21, *Cyathus Olla*; 22, *Nidula candida*; 23, *Crucibulum vulgare*.

24, 25, 26, 27. "Bird-cage" Fungus (*Clathrus cibarius*).

An interesting fungus found in Australia and New Zealand. The plant develops underground, an "egg" (Fig. 24; Fig. 25 is "egg" in section) being formed in which the plant practically reaches maturity before rupture occurs. Following the rupture of the apex of the egg, the white lattice-like structure emerges so rapidly as to be completely expanded in three or four hours (Fig. 27).

The spores are contained within a gelatinous matrix, lining the inner surfaces of the arms of the latticed structure. The whole is extremely fetid, and in consequence attracts flies; these feed upon the mucilage, and the spores are in this manner dispersed.

The rapid appearance on the surface of the ground of these latticed structures led to much speculation by the Maori as to their origin. He finally came to the conclusion that they were *tutae kehua* or *tutae whetu* (literally "fæces of ghosts" or "fæces of stars").

28–32. "VEGETABLE CATERPILLARS."

These fungi attack the larvæ (or adults) of various insects. The animal matter is replaced by fungous tissue, all but the chitinous exterior being completely replaced, a sclerotium being formed. From the sclerotium is produced a stalk-like fructification which grows to the surface of the substratum in which the insect happens to be.

Six species are found in New Zealand, all but two being endemic: 28, *Cordyceps Robertsii;* 29, *Cordyceps Aemonae;* 30, *Cordyceps Craigii* (on left) and *Cordyceps consumpta* (on right); 31, *Cordyceps Kirkii;* 32, *Isaria Sinclairii.*

33–37. SELECTED "RUSTS" ATTACKING VARIOUS PLANTS.

33. PELARGONIUM-RUST (*Puccinia granularis*).—This rust is common throughout on cultivated "geranium" (*Pelargonium zonale*). It produces unsightly reddish blotches on the leaves, which later in the season become surrounded with broad, dark-brown rings. No satisfactory method of dealing with this rust is known.

34. "LAWYER-RUST" (*Hamaspora acutissima*).—The peculiar thread-like structures on this leaf are composed of masses of spores. The fungus is confined to the one host plant, lawyer (*Rubus australis*).

35. FERN-RUST (*Milesina Histiopteridis*).—This, the only fern-rust present in New Zealand, forms minute spots on the leaves of *Histiopteris incisa.*

36. KOWHAI-RUST (*Aecidium kowhai*).—This rust forms large "witch's brooms" upon the branches of the kowhai (*Edwardsia tetraptera*). A branch becomes infected near the tip, and as a result numerous short lateral branches grow out from this infection centre. These give rise to tertiary branches, and so the whole assumes a shrubby appearance. The mycelium is perennial, consequently the fungus appears year after year on the same host.

37. CLEMATIS-RUST (*Aecidium otagense*).—This species produces large inflated areas on the shoots and inflorescences of several species of *Clematis*. The mycelium is perennial, consequently once a plant has become infected, the rust appears season after season on the same host. The small cup-shaped structures present in the infected tissues are æcidia—structures containing chains of spores.

PLANT-DISEASES.

The following are photographs of different diseases of plants arranged according to the host.

FRUIT-TREE DISEASES.

These are arranged under three headings—"Pome-fruit Diseases," "Stone-fruit Diseases," and "Citrus Diseases," and under each the diseases are placed alphabetically in order of their common names. For particulars regarding remedial treatment of any fruit-tree disease, see a book entitled "Fungous Diseases of Fruit-trees in New Zealand and their Remedial Treatment," where may be obtained details of each and every disease, together with life-history and treatment. Particulars regarding this book may be obtained from the Publications Section.

POME-FRUIT DISEASES.

38. Apple-spot (*Phoma Pomi*) on Apple-fruit.

    Brightly coloured spots are produced on the fruit as a result of infection. The disease is seldom troublesome in the orchard, for it makes its appearance as a rule only after the fruit has been for some time in store.

39. Bitter-pit on Pear-fruit.

    This fruit has been sectioned to show the brown spots scattered through the flesh.

40. Bitter-pit on Apple-fruit.

    Typical condition as it appears on the apple.

41. Bitter-pit on Apple-fruit.

    The confluent condition which appears only when the disease is prevalent. Bitter-pit is a non-parasitic or physiologic disease, and is confined to the apple and pear. Its cause is unknown.

42. Bitter-rot (*Glomerella cingulata*) on Apple and Pear Fruits.

    A disease which causes rotting of fruits, spotting of leaves, and (occasionally) forms large cankers in the stem and branches.

43. Black-rot (*Physalospora Cydoniae*) on Pear-branch.

    This disease attacks fruits, leaves, and branches. In New Zealand its effects are confined chiefly to branches, on which it produces cankers such as this. The concentric crevices are characteristic of infection at an early stage.

44. Black-rot on Pear-branch.

    Large cankers, such as this, are frequently produced by this disease on two- and three-year-old branches of pear-trees.

45. Black-spot (*Venturia inaequalis*) on Apple-fruit.

    Unsightly greenish or black blotches are produced on the fruit, leaves, and shoots. This is the most serious pome-fruit-tree disease in New Zealand.

46. Black-spot on Apple-fruit.
Infection is frequently followed by the appearance on the fruit of large scabbed areas such as this.

47. Blister-disease (*Coniothecium chomatosporum*) on Apple-shoot.
Small greenish blisters are produced on one- and two-year-old shoots.

48. Blister-disease on Apple-shoots.
An unusual condition where the blisters have increased in size very considerably and have become creviced, offering excellent openings for the penetration of numerous canker-producing fungi.

49. Blister-disease on Apple-fruit.
A common trouble on certain apple varieties, notably Dunn's Favorite and Cox's Orange, although invariably attributed to other causes. The disease is especially troublesome on light lands and stunted trees.

50. Blister-disease on Immature Pear-fruit.
Hard scabbed areas are produced, usually near the calyx.

51. Blister-disease on Mature Pear-fruit.
Complete delay of the fruit follows infection at this late stage.

52. Botrytis-rot (*Botrytis cinerea*) on Pear-fruit.
This disease is the cause of a calyx-rot of the apple, and has this past three seasons become a serious storage rot of apples and pears. Where prevalent its presence is an indication of too high a humidity of the store.

53. Circular-spot (*Phyllosticta Pirina*) on Apple-leaf.
Small yellow circular spots are formed in the leaf. It is doubtful whether this disease does much damage, although where infection is severe a certain amount of premature leaf-fall follows.

54. Circular-spot on Leaf.
One of the spots greatly enlarged to show the fructifications of the causal organism.

55. Delicious-spot (*Phomopsis Pomi*) on Apple-fruit.
A serious storage rot attacking apples, especially the varieties Delicious and Docherty.

56. Fabraea-scald (*Fabraea maculata*) on Quince-fruit.
Black depressed spots are produced on the fruits, spots on the leaves, and small cankers in the shoots.

57. Fabraea-scald on Quince-fruit.
Spots enlarged to show their depressed, zoned nature.

58. Fabraea-scald on Quince-leaves.
The spots at first are a purple colour, but soon enlarge and change to brown. Both young and old spots may be seen in the photo of the leaf on the left.

59. Glassy-core of Apple-fruit.
Affected fruits possess peculiar glassy or watery patches running through the flesh. If such fruits are held in store (not cool store) for a few weeks this trouble disappears, showing the trouble is non-parasitic.

60. Mouldy-core of Apple-fruit.

As its name implies, the core of affected fruits becomes mouldy. Spores—wind- or water-borne—are carried through the open channel between the calyx and core to the fissured core. Here they germinate and set up decay. Numerous fungi may produce this condition, provided they gain entry to the core of the fruit. Entry is in all cases effected through the open channel. Varieties possessing this defect should be avoided.

61. Pear-scab (*Venturia Pirina*) on Pear-fruit.

A disease closely resembling black-spot of apples, differing only in minor details. Infection is usually followed by severe scabbing and cracking of the fruit.

62. Pink-rot (*Trichothecium roseum*) on Apple-fruit.

This disease is an uncommon one. When present it infects fruits through skin-injuries, such as black-spot or blister-disease lesions.

63. Powdery Mildew (*Podosphaera leucotricha*) on Apple-leaves.

This is a serious disease of the apple, especially in the warmer localities, such as Otago Central. Note the manner in which the leaves become crumpled and distorted. Growth is hindered, with the result that numerous short and stunted laterals appear in place of more vigorous growth.

64. Powdery Mildew on Apple-shoot.

White mycelial masses are formed on infected shoots, and it is by means of these the disease persists season after season. Removal of these shoots greatly assists control.

65. Powdery Mildew on Apple-fruit.

Russeting of the fruits invariably follows on trees infected with this disease. Such disfigurement greatly impairs their market value.

STONE-FRUIT DISEASES.

66. Bladder-plum (*Taphrina Pruni*) on Plum-fruits.

With Japanese plums infection is frequently so severe as to lead to the loss of three-fourths of the crop. Infected fruits become greatly inflated, much wrinkled, and change in colour from a normal green to a dingy white. Healthy plums are shown above the infected ones.

67. Bladder-plum on English Plum (Evans's Early).

Infection on other than Japanese plums is unusual. With these specimens the fruit has not become swollen to the same extent (see normal plum on the left).

68. Infected and Normal Plums.

This photo shows a gradual transition from healthy fruit (on right) to severely infected (on left).

69. Infected and Normal Plums in Section.

Infected fruits are much larger in size, but are hollow, whereas normal plums contain the well-nourished ovules.

70. BROWN-ROT (*Sclerotinia cinerea*) ON PEACH-FRUIT.

Masses of fructifications cover the surface, giving the whole fruit an ashy-grey colour. This is the most serious of all diseases attacking stone-fruits, for it destroys fruits, leaves, and shoots.

71. BROWN-ROT ON SHOOTS.

Infection is invariably followed by death of the lateral. Blossoms are frequently killed at this stage, when they become attached to the lateral by gummous exudates.

72. BROWN-ROT MUMMIES PRODUCING APOTHECIA.

Should infected fruits fall to the ground they may the following spring produce saucer-shaped fructifications termed "apothecia." From these structures very numerous spores are produced, which at blossoming infect flowers and shoots. (See Fig. 6.)

73, 74. LEAF-RUST (*Puccinia Pruni-spinosae*) ON PLUM-LEAF.

This leaf is covered with rusty-brown spots consisting of very numerous spores. These are produced abundantly throughout the growing season. They infect leaves, fruits, and even shoots. The disease is common on apricot, cherry, nectarine, peach, and plum. Its life-history (in Europe) is a complex one, for no less than four spore stages are produced. The cycle is further complicated in that one stage is produced on leaves of the cultivated *Anemone*, a plant widely separated botanically from stone-fruits.

This complex history may be illustrated by the following drawings: In the spring on anemones appear bright-yellow cup-like structures termed "æcidia," in which are produced chains of spores (Fig. 74, *a*). These spores infect leaves or fruits of stone-fruits, and give rise to a mycelium which produces spore-bearing structures (Fig. 74, *b*) termed "uredosori." Uredospores produced in this manner infect other leaves, &c., throughout the growing season. In autumn arises a third type of spore—teleutospore (Fig. 74, *c*), or resting spore. This overwinters and in the spring germinates, producing basidiospores, which infect anemones, thus completing the cycle. In New Zealand, however, it appears that owing to the rarity of the æcidial stage the fungus overwinters by means of the uredospores.

75. LEAF-RUST ON PLUM-LEAF.

These spores are teleutospores, which in New Zealand are functionless.

76. LEAF-RUST ON ANEMONE-LEAF.

This—the æcidial stage—is rare in New Zealand.

77. LEAF-CURL (*Taphrina deformans*) ON PEACH-LEAVES.

Distortion of leaves, fruits, and shoots follows infection. Frequently the leaves change colour from a normal green to yellow or even red. Infected leaves prematurely fall, so where infection is severe, defoliation is inevitable.

78. Peach-scab (*Cladosporium carpophilum*) on Peach-fruit.
This disease forms small discoloured spots on peach and nectarine fruits and shoots.

79. Peach-scab on Peach and Nectarine Fruits.
Severe infection is followed by cracking and splitting of the fruit.

80. Root-knot (*Phytomonas tumefaciens*) on Peach-seedlings.
This disease—a bacterial one—produces inflated galls on the crown and roots. Although it may prove a serious disease of nursery stock, it has little detrimental effect upon trees in the orchard.

81. Shot-hole (*Phyllosticta Prunicola*) on Japanese Plum Leaves.
A characteristic disease in which the leaves appear as if riddled with shot. Where infection is severe partial defoliation may follow. The disease also produces scabs and malformations on the fruit.

82. Shot-hole on Plum-leaf.
Enlarged to show the nature of the perforations.

83. Silver-leaf (*Stereum purpureum*) on Peach-tree.
These, the fructifications of the causal organism, appear on those branches the leaves of which have shown signs of silvering. From them are produced spores, which, if carried to unprotected wounds in neighbouring trees, penetrate and set up the silver-leaf condition.

84. Silver-leaf Discoloration of Wood.
This discoloration is characteristic of wood infected by the silver-leaf organism. Penetration of this branch has been by way of the stub on the left.

CITRUS DISEASES.

85. Frost-injury on Lemon-fruits.
Small, discoloured, frequently creviced areas are formed in the cortex. Although not in themselves serious (apart from their disfiguring nature), these injuries allow of the penetration of soft rotting fungi.

86. Malformed Lemon-fruits.
This condition is due to the conversion of certain of the floral parts into pulp-cells and cortex. Buds from trees producing these fruits should be avoided.

87. Sun-scald on Citrus-leaves.
Small brown spots are formed on the underside of the leaf. The damage is insignificant.

88. Sooty-mould (*Capnodium citricolum*) on Lemon-leaves.
Discoloured soot-like patches are formed on the surfaces of the leaves, shoots, and fruits. Apart from this disfigurement sooty-mould does little damage, for it is entirely superficial, growing as a thin film over the host-surface. It develops only when scales or mealy-bug are present, living on a substance termed "honeydew" secreted by these insects. If these pests are destroyed, sooty-mould quickly disappears.

89. Citrus-verrucosis (*Sporotrichum Citri*) on Lemon-fruits.
This disease produces scabs on fruits, leaves, and shoots; in addition it causes fruits to become knobbed and roughened. It is the most serious disease attacking citrus-trees.

GRAPE DISEASES.

90. Grape-anthracnose (*Glomerella cingulata*) on Fruit.
This disease attacks fruits, leaves, and shoots. On shoots it forms small black cankered areas, which render them brittle. On fruits small sunken-spots are produced which render them useless for the market.

91. Grape-mildew (*Uncinula necator*) on Fruit.
Attacks leaves, shoots, and fruits, covering the first with a greyish mould, and causing splitting of the last. The disease may be held in check with one or two applications of precipitated sulphur.

92. Grey-rot (*Sclerotinia Fuckeliana*) on Fruit.
This disease completely destroys the fruit. Fortunately it is a disease which may be held in check by proper attention to ventilation, becoming prevalent only when the house humidity is high.

FIELD-CROP DISEASES.

Only exhibits of those diseases which have been or are being investigated in the laboratory are presented.

CEREAL-DISEASES.

93. Stinking-smut (*Tilletia Tritici*) of Wheat.
The infected ovaries are difficult to detect, but may be recognized by their darker colour and different shape. Diseased plants emit a characteristic smell, resembling that of decaying fish.

94. Stinking-smut of Wheat.
The glumes have been dissected away to show the infected ovaries, and these in turn sectioned to show the spore-masses of the smut. Owing to the universal practice of "pickling" seed before sowing, the effects of this disease on the wheat crops of New Zealand are slight.

95. Oat-smut (*Ustilago levis*).
This smut destroys completely the inflorescences, converting them into a black powdery mass. It has become a troublesome disease in recent years, especially on farms where "pickling" of the seed before sowing has not been adopted.

96. Covered-smut (*Ustilago Jensenii*) on Barley.
The inflorescences are converted into compact black masses. In threshing these are broken up, and the spores adhere to the surfaces of normal seeds.

All of these smuts may be controlled by steeping ("pickling") the seed in some suitable fungicide. In the past, formalin and bluestone have been widely used, but, owing to their damaging effects upon the grain, these

in recent years have been replaced by other compounds, of which one of the most efficient is copper-carbonate dust. For particulars as to its use see *New Zealand Journal of Agriculture*, vol. 30, p. 302, 1925.

97. LOOSE-SMUT (*Ustilago Tritici*) ON BARLEY.

98. LOOSE-SMUT ON WHEAT.

This smut attacks the inflorescences of both wheat and barley, and hitherto has proved the most serious of all the cereal smuts, for it is not held in check by "pickling."

The staff of the Mycological Laboratory have evolved a satisfactory treatment for this smut. This, the hot-water treatment, owing to the need for exactness, is not a farmer's treatment. It is intended, however, to treat seed in bulk sufficient to sow an area large enough to supply quantities of clean seed to growers.

Particulars of treatments may be obtained from *New Zealand Journal of Agriculture*, vol. 30, p. 167, 1925.

99. ERGOT (*Claviceps purpurea*) ON WHEAT.

This fungus is rare on cereals in New Zealand, but abundant on grasses, especially cocksfoot, rye-grass, and tall fescue.

GRASS-SMUTS.

The following four grass-smuts have been selected to show the appearance and effects of these fungi on different grasses. Most of these smuts are confined to the one host, or at best to related species of the same host genus.

100. OAT-SMUT (*Ustilago Avenae*) ON TALL OAT-GRASS.

The same species also occurs on oats.

101. BROME-SMUT (*Ustilago bromivora*) ON PRAIRIE-GRASS.

This species destroys the inflorescence of numerous species of *Bromus*.

102. TWITCH-SMUT (*Ustilago bullata*) ON *Agropyron scabrum*.

A rare species found in Australia and New Zealand.

103. SEDGE-SMUT (*Sorosporium Neillii*) ON *Scirpus nodosus*.

POTATO - DISEASES.

104. POWDERY SCAB (*Spongospora subterranea*).

Small blisters on the surface of the tuber are produced by this organism. The disease is confined to those localities which are low-lying or possess an abundant rainfall. Should such areas be avoided in planting, little or no infection would ensue, even though diseased seed were used.

105. COMMON SCAB (right) AND POWDERY SCAB.

This photo shows the differences between these two diseases. Common scab may be combated by immersing the tubers before sowing in the same solution recommended for the control of corticium-disease.

106. MATTERY-EYE (*Phytobacter Solanaceara*).

Note the discoloured ring characteristic of the disease. Mattery-eye is a bacterial disease transmitted by infected tubers. Avoidance of diseased seed is the only preventive treatment that can be recommended.

107. CORTICIUM-DISEASE (*Corticium Solani*).

The small black bodies on the tuber are the structures by which the fungus is disseminated. Destruction of these ensures a clean crop.

Steeping the tubers in an acidulated solution of mercuric chloride has proved the most efficient controllant. For preparation of this solution and method of use see *New Zealand Journal of Agriculture*, vol. 30, p. 93, 1925.

108. SCAB PRODUCED BY CORTICIUM-DISEASE.

This scabbing is characteristic of the skin-injury produced by this disease.

109. BROWN-FLECK.

A disease the cause of which is unknown. One worker claimed it to be bacterial, but his statement lacks substantiation. It is by most workers considered to be non-parasitic.

110. CLUB-ROOT (*Plasmodiophora Brassicae*) ON RAPE.

This disease is widespread throughout the world. No preventive treatment is known, but its onset is lessened where four- to five-year rotations are practised.

In the grass-garden, plots 29, 30, and 31 are small areas of wheat arranged to demonstrate the following experiments in cereal-smut control :—

PLOT 29 (No. 1): Stinking-smut experiments.

Variety : Solid-straw Tuscan.

Treatment : Five rows treated for one hour with 0·25-per-cent. solution of "Uspulun"; five rows untreated.

PLOT 29 (No. 2):

Ten rows treated with Stauffer's copper-carbonate dust; ten rows treated bluestone (2 per cent.) for ten minutes.

PLOT 30 (No. 3): Loose-smut experiments.

Variety : Major.

Treatment : Five rows untreated; five rows treated with hot water, presoaked six hours at 80° F., dipped ten minutes at 127° F.

PLOT 30 (No. 4): Covered-smut of barley experiments.

Variety : Chevalier.

Treatment : Five rows untreated; five rows treated with hot water, presoaked six hours at 80° F., dipped 10 minutes at 125° F.

PLOT 31 (No. 5): Oat-smut experiments.

Variety : Garton.

Treatment : Ten rows untreated.

(No. 6): Ten rows treated for three hours in a 0.25-per-cent. solution of "Uspulun."

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